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Abstract

Information is presented on establishment, survival, and growth of seven selected browse species in a ponderosa pine forest over a 10-year period. Methods of establishment included hand seeding and planting bare-root and containerized stock. Success of different methods differed with shrub species.

Acknowledgment

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MANAGEMENT IMPLICATIONS

The results of this study indicate that shrub species can be successfully reestablished on both old-burn and open-pine sites in the Black Hills. For best success, the choice of shrub species should be coupled with the most suitable planting technique. Competition from native grasses and forbs should be reduced. Observations indicate that the key to revegetation of game ranges in the Black Hills by shrub planting may be the fortuitous occurrence of several years having 18 inches of precipitation or more, providing continuous moisture during the critical stage of root establishment and development.

Silver buffaloberry and silverberry grew to large size on both burned and unburned areas. Saskatoon serviceberry grew moderately well on the unburned area, and common chokecherry growth was fair on both areas. Silverberry was by far the most vigorous root sprouter, producing many new plants in the vicinity of the parent plant. This species would be a good choice for planting where browsing pressures are a problem because it has a lower palatability for deer and cattle. It provides good cover for large and small game, buds and berries for birds, and emergency food for deer during critical winter periods.

Common chokecherry and saskatoon serviceberry are questionable for planting because of exacting site requirements for good growth. Both of these species are rootsprouters and will spread when site conditions permit.

Antelope bitterbrush and mountainmahogany were the only seeded species studied that offer much promise for revegetating game ranges. Mountainmahogany has a very restricted range in the Black Hills, and no antelope bitterbrush was found in the area. However, the limited success of seeding antelope bitterbrush in this study would tend to recommend it for browse habitat improvement in the Black Hills. When costs are not a major consideration and full stock is desired, the use of bare-root stock is much more effective. With this method, moisture conditions must be proper to permit root elongation and enhance survival.

It must be remembered that good seed years combined with several years of good precipitation are rare. These conditions, coupled with low populations of rodents and large herbivores and, in addition (but very important), the presence of disturbed sites where growing space is available, happen infrequently. Therefore, one should expect more failures than successes. Nevertheless, on critically needed deer ranges where only a few remnant shrubs remain, palatable and nutritious browse species can be reestablished with techniques described in this study.

A comparison between the old-burn and the open-pine sites indicated that hand-seeded shrubs and those planted as containerized stock survived and grew better on the burn. Shrubs planted as bare-root stock survived and grew well on both sites. Containerized seedlings had a higher survival at the end of 10 years than plants established from hand seeding in the field. However, there was little difference in growth of the shrubs between planting methods. Mortality for all shrub species was highest during the first 2 years on both sites. There was little mortality for the remaining 8 years of the study.

Hand seeding mountainmahogany and antelope bitterbrush was most promising for revegetation because they had better growth and survival than other species. Establishment of common chokecherry by bare-root stock was the most effective method. Silverberry and silver buffaloberry grew best of the species established by bare-root stock.

The most successful method overall of establishing shrubs on both sites was by planting bare-root stock. Planting containerized seedlings was the next most successful (table 1). Hand seeding in the fall was least effective, but suitable for some species such as antelope bitterbrush.

Results from this 10-year study indicate that shrubs can be reestablished on depleted game ranges in the central Black Hills of South Dakota.

Table 1.—Summary of the most effective planting methods of individual shrub species and rating of species for establishment, survival, and growth on old-burn and open-pine sites

Species	Best method[1] both sites	Establishment success[2]		Survival[2]		Growth[2]	
		Burn	Pine	Burn	Pine	Burn	Pine
Antelope bitterbush	C	G	M	G	G	G	M
Silverberry	B	F	F	M	F	G	G
Common juniper	B	F	F	F	P	F	F
Common chokecherry	B	M	M	M	M	P	P
Silver buffaloberry	B	F	F	F	F	G	M
Mountainmahogany	C	M	M	M	M	F	F
Saskatoon serviceberry	B	F	F	F	F	P	P

[1]*C—Containerized stock; B—Bare-root stock.*
[2]*Rating system: G—Good; M—Moderate; F—Fair; P—Poor.*

INTRODUCTION

A major problem in managing deer in the Black Hills of South Dakota and in much of the western United States has been the loss of good deer habitat through continued deterioration of staple browse plants on old-burn winter ranges (Berner 1953, Bever 1959). Similar deterioration exists on sites occupied by ponderosa pine. Many shrub species are not able to complete successfully with grass, forbs, and pine. Native browse species sometimes have low vigor on some overbrowsed ranges even after grazing has been reduced. The shrubs are mostly old and decadent; regeneration is poor or absent. On ranges where native shrubs can no longer revegetate depleted areas, introduction of new shrubs and/or reintroduction of native species may be the best way to improve the supply of browse plants.

Although browse planting and seeding is considered expensive and impractical in the eastern states (Bartlett 1950, Latham 1950), it has been successful in many western states (Holmgren 1954; Hubbard et al. 1959; Plummer et al. 1962, 1964, 1968; White and Boyd 1957; Springfield 1972). Springfield (1972) presented data on germination and growth of game forage species in New Mexico. Plummer et al. (1962) found first-year establishment of browse species from direct seeding depends on a coincidence of good precipitation, absence of competition, and favorable temperatures in the early spring period.

Much of the work on shrub revegetation in the West has been with antelope bitterbrush (*Purshia tridentata*) (Brown and Martinsen 1959, Holmgren and Basile 1959, Hubbard 1964). Nord (1965) gives a review of the autecology of antelope bitterbrush in California. Wagle (1958) reported on a comprehensive study of early growth variation in antelope bitterbrush and its relation to the environment.

There have been only limited shrub planting trials in the Black Hills (McEwen and Hurd 1959). Berner (1953) suggested reseeding or planting browse species coupled with some method of control or reduction of deer as a means of improving deer winter range.

The objectives of this study were to determine (1) the germination success of seeding trials in the field at two sites, (2) the germination of shrubs in the greenhouse, (3) which shrub species were best suited to the environment, and (4) how to effectively establish superior shrubs on two important deer habitat types in the ponderosa pine forests of the Black Hills of South Dakota.

STUDY AREA AND METHODS

Two study sites were selected on the Black Hills National Forest. The old-burn study site, 10 miles north-northwest of Hill City in the Black HIlls of South Dakota, was near the center of the McVey burn, a large area (21,857 acres) burned by wildfire in 1939 (fig. 1). This area has become one of the most utilized deer winter ranges in the Black Hills. Native vegetation on the planting site consisted of saskatoon serviceberry (*Amelanchier alnifolia*), Woods rose (*Rosa woodsii*), little bluestem (*Andropogon scoparius*), fringed sagebrush (*Artemisia frigida*), common snowberry (*Symphoricarpos albus*), and Kentucky bluegrass (*Poa pratensis*). The open-pine site, 15 miles north-northwest of Hill City, is on the edge of the main winter deer range (fig. 2). This site has an open stand of mature ponderosa pine (*Pinus ponderosa*) with a sparse understory of bearberry (*Arctostaphylos uva-ursi*), and scattered remnants of common chokeberry (*Prunus virginiana*) and saskatoon serviceberry. Wild strawberry (*Fragaria ovalis*) and groundplum milkvetch (*Astragalus crassicarpus*) are common forbs on the area. Fire scars on the mature pines and charcoal in the soil indicate that the area burned prior to 1900.

In the Black Hills, approximately 70% of the precipitation falls during the growing season, May through September, as shown below (in inches):

Month	Old-burn site	Open-pine site
January	0.50	0.53
February	0.69	0.74
March	0.87	0.82
April	2.08	2.21
May	3.36	3.79
June	4.20	4.11
July	3.19	3.41
August	1.87	1.94
September	1.35	1.23
October	0.61	0.56
November	0.75	0.77
December	0.54	0.54

Figure 1.—The shrub planting site on the old-burn site rapidly reforested with ponderosa pine between the initiation of the study (A) and 10 years later at its termination (B).

Figure 2.—The open-pine site, typical of deer ranges in the central Black Hills, is dominated by open ponderosa pine.

Precipitation normally increases during May and reaches a maximum in June. Annual precipitation decreased each year for the three planting years. Total annual and growing season precipitation at the open-pine site exceeded that at the old-burn site as shown below (in inches):

Year	Old-burn site	Open-pine site
1	18.7	21.4
2	16.3	18.9
3	15.2	16.6
4	15.5	14.9
5	24.8	26.2
6	23.6	24.2
7	19.2	22.3
8	26.9	28.9
9	16.9	17.0
10	24.4	21.0
11	16.9	15.0
Average	19.8	20.6

Soils on both sites are of metamorphic schist parent material, top soil depths are similar (5-6 inches), and slopes are comparable (36%-39%). The sites are in the 18- to 20-inch annual precipitation zone in the Black Hills. While the sites are physiographically comparable, they represent two specific deer habitat types.

Seven-foot-high fences were built on each site to protect an area 60 by 100 feet from livestock, deer, and rabbits. The exclosures were subdivided into three plots each 33 by 60 feet. These plots were randomly assigned a year to be planted—first, second, or third. The plots were further divided into two 30- by 33-foot subplots. These subplots were randomly assigned for spring or fall planting. Nine rows, 3 feet apart and 15 feet long, were established on the contour in each subplot. Shrub species were randomly assigned to these rows.

Planting techniques were (1) hand seeding in the fall, (2) containerized seedlings planting in the spring, and (3) spring planting of bare-root stock.

Germination

The following plants were hand seeded: antelope bitterbrush, common chokecherry, comon juniper (*Juniperus communis*), pin cherry (*P. pensylvanica*), mountainmahogany (*Cercocarpus montanus*), and snowbrush ceanothus (*Ceanothus velutinus*). Seeds were collected locally the year prior to planting except for antelope bitterbrush which was collected in Idaho because it does not occur in the Black Hills. Seeds were not treated prior to sowing except that one-half of the antelope bitterbrush seeds were treated with a toxicant/repellent to discourage rodents. Seeds were sown approximately 2 inches apart and 1 inch deep in hand-cultivated rows.

The following species were seeded in the greenhouse: antelope bitterbrush, common chokecherry, common juniper, pin cherry, mountainmahogany, and snowbrush ceanothus. All seeds and fruits were stratified from 39 to 99 days in moist vermiculite at 45° F. Common chokecherry seeds were scarified to break dormancy. In addition, snowbrush ceanothus seeds were soaked in boiling water and 3% thiourea solution to break dormancy. Three to five stratified seeds were planted in a mixture of three parts soil to one part washed river sand in a tar-paper pot. Germination was recorded biweekly during the early growing season both in the field and in the greenhouse.

Establishment of Shrubs

The following containerized species were planted in the spring: antelope bitterbrush, common chokecherry, common juniper, pin cherry, mountainmahogany, and snowbrush ceanothus (fig. 3). Seedlings were hardened in cold frames for 1 month prior to field planting in early May.

Bare-root nursery stock of common chokecherry, saskatoon serviceberry, silverberry (*Elaeagnus commutata*), silver buffaloberry (*Shepherdia argentea*), and common juniper were obtained from commercial nurseries and planted during the latter part of April. A trench 6 inches deep was excavated along the contour of the slope in which shrubs were equally spaced at 18-inch intervals. All shrubs were watered at the time of planting.

The bare-root stock ranged in height from 6 to 9 inches for saskatoon serviceberry and 18 to 24 inches for silverberry. Common chokecherry, saskatoon serviceberry, and silver buffaloberry were top-pruned approximately one-third at the time of planting. The rows were cultivated by hand during the summer of each year.

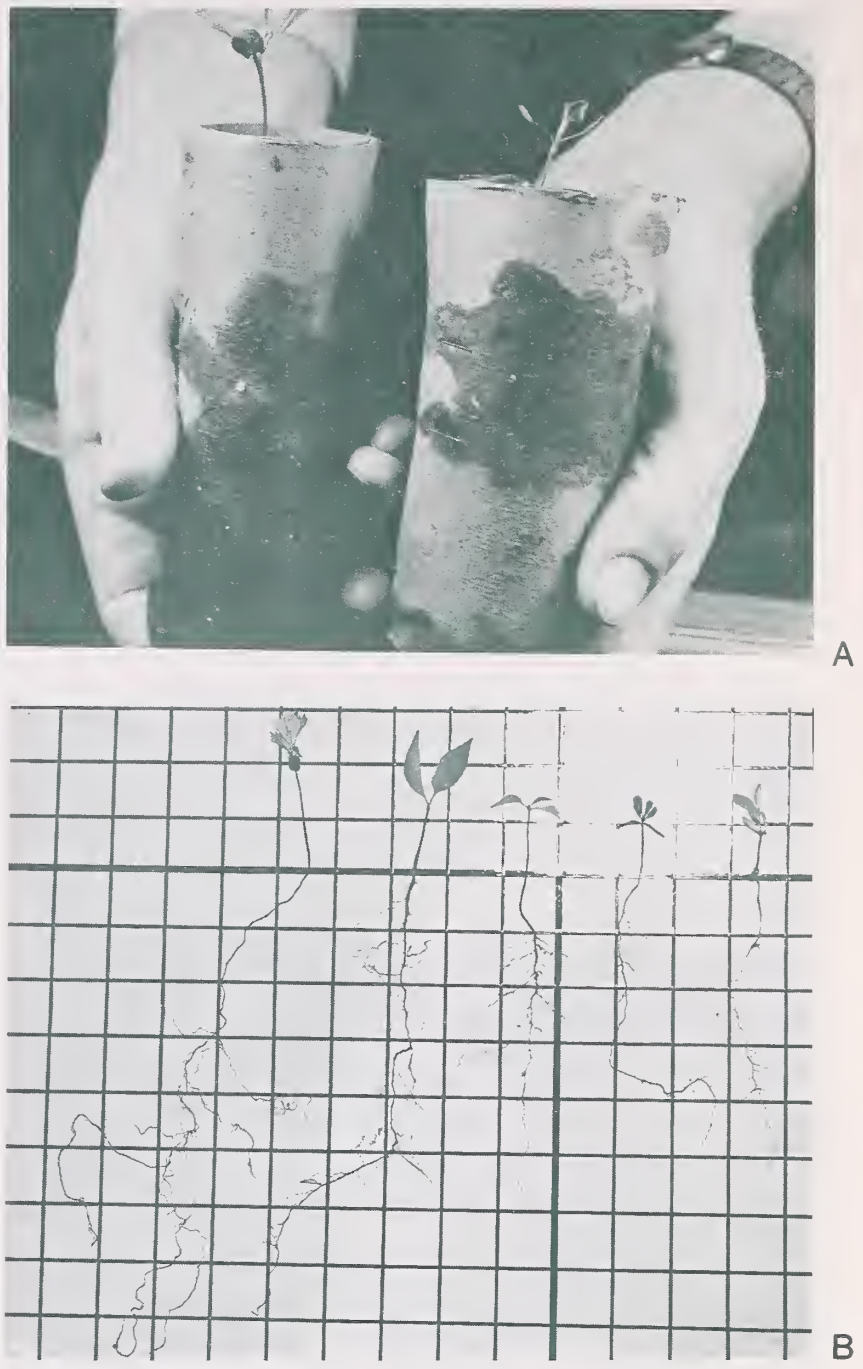


Figure 3.—Shown are the size and shape of tar-paper containers used for growing antelope bitterbrush seedlings in the greenhouse (A) and comparative size of potted seedlings (B) at time of field transplanting (from left to right): antelope bitterbrush, common chokecherry, pin cherry, mountainmahogany, and silverberry (1-inch squares).

Survival of the plants was recorded biweekly for eight growing seasons, and a final measurement was made 10 years after planting. Overwinter survival and total plant height was recorded during the first week of May and September of each year.

RESULTS

Germination of Shrubs

A factorial analysis of variance was used to compare the germination success of mountainmahogany, common chokecherry, and treated and untreated antelope bitterbrush on the two sites for 3 years on two replicated

rows. There were differences among sites ($p \leq 0.01$), years ($p \leq 0.05$), and species ($p \leq 0.10$). There was a significant ($p \leq 0.05$) interaction between site and years, but no differences between replications. The toxicant/repellent-treated antelope bitterbrush seeds generally had a germination success averaging 5%-10% higher at the burn and pine sites, respectively (table 2).

Antelope bitterbrush germination was higher than either mountainmahogany or common chokecherry at both locations, while the latter two species showed about equal germination. Many of the fall seeded species including common juniper, pin cherry, and snowbrush ceanothus, had little or no germination on either site, indicating the need for either preseeding treatment or more favorable planting conditions.

Germination in the greenhouse varied considerably among species. Antelope bitterbrush seeds germinated best with an overall average of 49% (table 3). The success of other shrubs in germinating ranked as follows: mountainmahogany > common chokecherry > snowbrush ceanothus > pin cherry. Common juniper seeds and fruits could not be germinated.

Establishment of Shrubs

Fall Seeding

Fall seeding at the burn site showed that survival after the first growing season decreased for antelope bitterbrush, mountainmahogany, and common chokecherry (table 4). After 10 years, antelope bitterbrush exhibited the highest survival rate (22%). Mountainmahogany had the least number of plants surviving after 10 years (4%). Common chokecherry showed the greatest loss in survival, decreasing from 42% the first year to 6% the tenth year.

On the open-pine site, survival of the three shrub species from fall seeding decreased after the first growing season to the tenth growing season (table 4). Antelope bitterbrush had the highest survival after 10 years with 8%. During the tenth growing season, mountainmahogany and common chokecherry had survival rates of approximately 3%.

Antelope bitterbrush seeded on the old-burn site had a higher survival at the end of the study than either

Table 2.—Germination of shrub seeds planted in the fall of 3 consecutive years on old-burn and open-pine sites

Species	Seeds planted	Percent germination			
		Year 1	Year 2	Year 3	Average
		percent			
Old-burn site					
Antelope bitterbrush[1]	180	28	31	[2] 24	27
Antelope bitterbrush	180	33	26	[2] 14	22
Common chokecherry	360	13	12	31	19
Mountainmahogany	360	38	6	14	19
Open-pine site					
Antelope bitterbrush[1]	180	46	44	[2] 32	39
Antelope bitterbrush	180	36	37	[2] 22	29
Common chokecherry	360	29	[3] 30	26	28
Mountainmahogany	360	38	15	24	26

[1] *Toxicant/repellent treated.*
[2] *Seeds planted—360.*
[3] *Seeds planted—180.*

Table 3.—Greenhouse germination of seeds of selected shrub species for 3 consecutive years

Species	Year 1		Year 2		Year 3		Average
	Planted	Emerged	Planted	Emerged	Planted	Emerged	
	number	*percent*	*number*	*percent*	*number*	*percent*	*percent*
Antelope bitterbush	1,100	48	400	34	1,440	54	49
Mountainmahogany	1,175	17	1,000	33	1,162	24	24
Common chokecherry	810	3	100	11	1,152	33	20
Snowbrush ceanothus	540	28	1,000	1	0	0	10
Pin cherry	640	0	400	3	612	3	2
Common juniper	850	0	300	0	216	0	0

Table 4.—Average survival of fall seeded shrub species (percent plus or minus standard error) over a 10-year period on old-burn and open-pine sites in the Black Hills of South Dakota

Species	Growing season[1]			
	First	Second	Fifth	Tenth[2]
Old-burn site				
Antelope bitterbush	51.7 ± 9.5	40.6 ± 9.7	23.9 ± 4.0	21.8 ± 5.0
Mountainmahogany	23.5 ± 6.4	15.4 ± 4.9	4.2 ± 2.4	4.2 ± 2.4
Common chokecherry	41.8 ± 7	25.9 ± 9.5	7.6 ± 7.6	6.3 ± 6.3
Open-pine site				
Antelope bitterbush	40.4 ± 7.5	19.0 ± 5.8	8.3 ± 4.2	8.3 ± 4.2
Mountainmahogany	27.8 ± 1.0	14.0 ± 2.6	10.1 ± 4.6	3.6 ± 1.9
Common chokecherry	32.2 ± 10.4	20.8 ± 15.3	7.0 ± 7.0	3.2 ± 3.1

[1]*Sample size n = 3 consecutive years; number of seeds planted each year by species ranged from 180-360.*

[2]*Final survival measurements represent an average of the ninth through eleventh years.*

antelope bitterbrush seeded at the open-pine site or common chokecherry and mountainmahogany seeded at either location. Mountainmahogany and common chokecherry survived poorly at both sites.

Growth of antelope bitterbrush established from fall seeding was superior to growth of mountainmahogany and common chokecherry on both old-burn and open-pine sites for the first 5 years (fig. 4). After 10 years, antelope bitterbrush and mountainmahogany were comparable and exceeded common chokecherry in height on both study areas. Furthermore, antelope bitterbrush and mountainmahogany had higher growth rates on the old-burn site than on the open-pine site, and after 5 years were almost twice as tall as common chokecherry. After 10 years, all three shrubs on the old-burn site were about one-third taller than those on the open-pine study area. Even though common chokecherry grew taller on the old-burn area than on the open-pine area, both sites were still producing only small plants after 10 years.

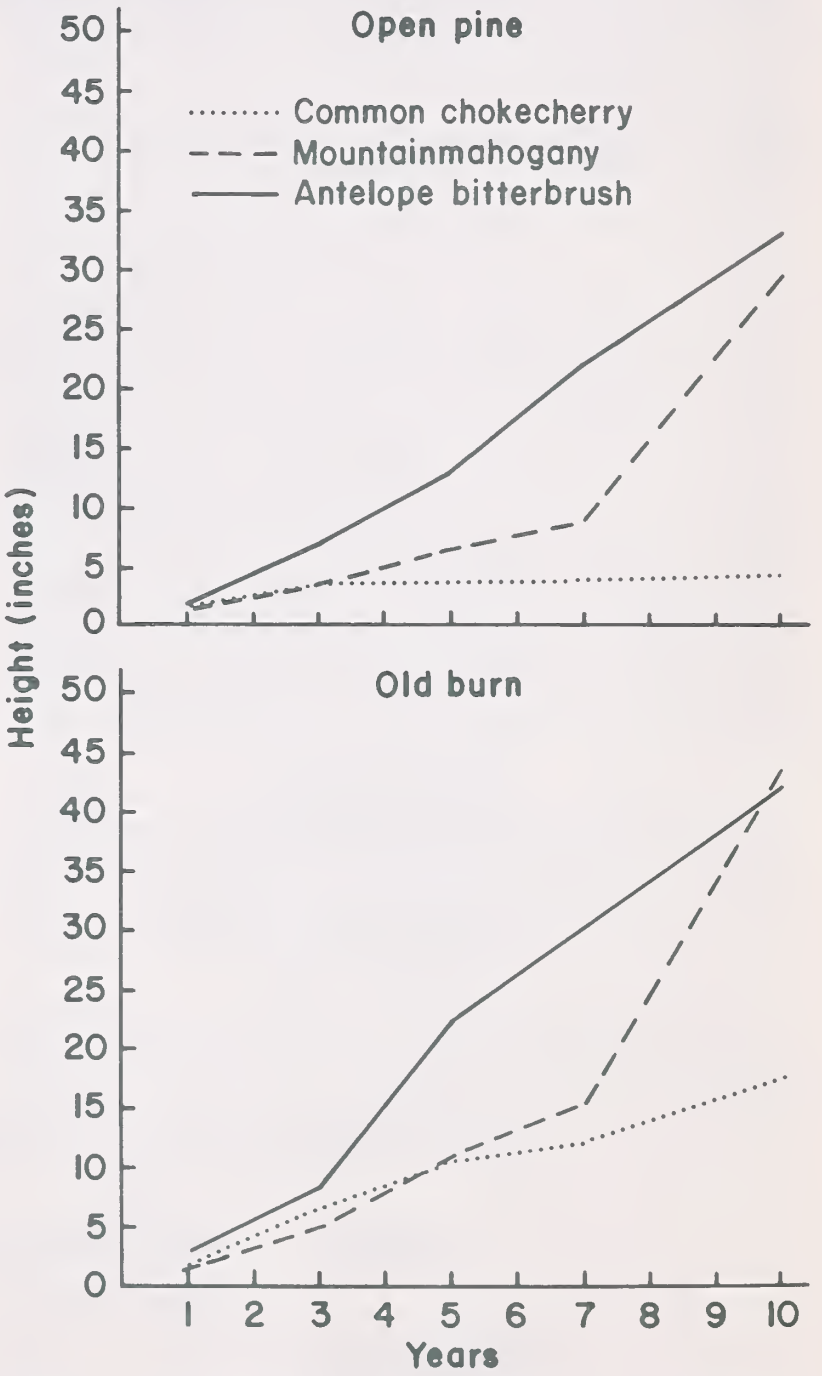


Figure 4.—Comparative growth curves shown for antelope bitterbrush, mountainmahogany, and common chokecherry established by fall seeding at the old-burn and open-pine sites for the first seven growing seasons and at the end of the tenth growing season.

Containerized Seedlings

Antelope bitterbrush and mountainmahogany plants grown in the greenhouse and transplanted to the field had a higher survival than common chokecherry seedlings established in the same manner (table 5). There was no survival of common chokecherry plants at the end of the fifth growing season. Antelope bitterbrush survived better on the old-burn site after 10 years, with a 20% survival rate; on the open-pine site, 11% survived. Mountainmahogany during the tenth year had survival rates of 18% and 7% on the open-pine and old-burn sites, respectively.

The growth rates were higher for antelope bitterbrush on both the old-burn and open-pine sites during the first 5- to 7-year period after plants were established when compared to mountainmahogany (fig. 5). By the tenth year, mountainmahogany was much taller than antelope bitterbrush (figs. 6 and 7).

Table 5.—Average survival of containerized planting stock of shrubs (percent plus or minus standard error) over a 10-year period on old-burn and open-pine sites in the Black Hills of South Dakota

Species	Growing season[1]			
	First	Second	Fifth	Tenth[2]
Old-burn site				
Antelope bitterbush	66.5 ± 14.9	36.4 ± 8.6	26.9 ± 8.3	20.2 ± 8.7
Mountainmahogany	62.4 ± 15.1	22.5 ± 2.7	7.4 ± 2.2	6.7 ± 2.5
Common chokecherry	21.4 ± 10.7	8.1 ± 8.1	0.0 ± 0.0	0.0 ± 0.0
Open-pine site				
Antelope bitterbush	56.9 ± 12.5	26.1 ± 4.6	14.2 ± 3.7	11.0 ± 4.1
Mountainmahogany	71.5 ± 10.4	37.1 ± 15.8	18.2 ± 7.5	18.2 ± 7.5
Common chokecherry	17.8 ± 9.7	4.5 ± 4.5	0.0 ± 0.0	0.0 ± 0.0

[1]*Sample size n = 3 consecutive years.*
[2]*Final survival measurements represent an average of the ninth through eleventh years.*

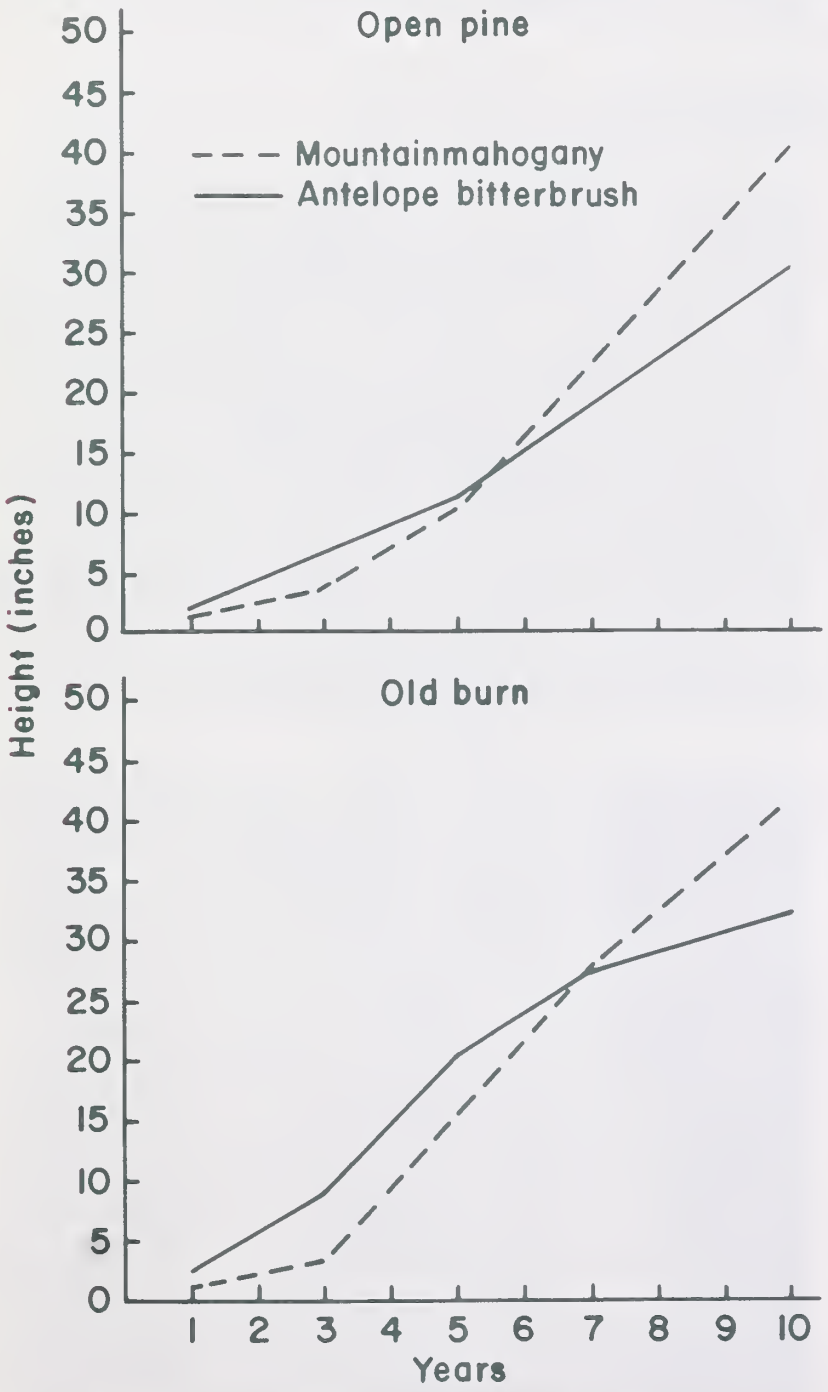


Figure 5.—Comparative growth curves are shown for antelope bitterbrush and mountainmahogany established by containerized seedlings at the old-burn and open-pine sites for the first seven growing seasons and at the end of the tenth growing season.

Figure 6.—Antelope bitterbrush grew rapidly and developed into large productive bushes in 10 years on the old-burn site (A), and performed nearly as well at the open-pine site (B). Grid interval in A is 1 foot.

Table 6.—Average survival of bare-root planting stock of shrubs (percent plus or minus standard error) over a 10-year period on old-burn and open-pine sites in the Black Hills of South Dakota

Species	Growing season[1]			
	First	Second	Fifth	Tenth[2]
Old-burn site				
Common chokecherry	80.4 ± 3.7	73.5 ± 7.1	47.7 ± 9.6	27.6 ± 9.9
Saskatoon serviceberry	69.1 ± 22.6	39.1 ± 9.5	3.7 ± 2.3	0.0 ± 0.0
Silverberry	57.8 ± 21.6	43.8 ± 22.3	35.8 ± 17.9	30.5 ± 15.4
Silver buffaloberry[2]	50.0	43.3	30.0	30.0
Common juniper	28.9 ± 14.9	15.5 ± 8.0	12.2 ± 6.2	12.2 ± 6.2
Open-pine site				
Common chokecherry	68.6 ± 13.9	46.2 ± 8.4	57.5 ± 12.5[3]	37.1 ± 11.9
Saskatoon serviceberry	91.7 ± 5.2	44.6 ± 24.6	40.9 ± 24.5	31.3 ± 21.3
Silverberry	50.0 ± 28.9	38.0 ± 22.1	32.2 ± 18.3	15.8 ± 8.1
Silver buffaloberry[2]	100.0	100.0	90.0	63.3
Common juniper	43.3 ± 22.7	22.2 ± 11.3	10.0 ± 6.9	6.6 ± 3.8

[1]*Sample size n = 3 consecutive years of plantings.*
[2]*n = 1 year.*
[3]*Increased percentage due to resprouting from original rootstocks.*
[4]*Final survival measurements represent an average of the ninth through eleventh years.*

Bare-Root Stock

Survival of bare-root stock for common chokecherry at both sites was higher during the first and second year than for plants started by fall seeding or containerized seedlings (table 6). With a few exceptions, saskatoon serviceberry transplants survived well the first year in the field, but many died the second year and, by the end of the tenth growing season, no live plants remained. Silverberry transplants generally had a higher survival during their first year in the field than silver buffaloberry and common juniper.

At the old-burn site, the survival of common chokecherry and silverberry bare-root transplants was higher than other species at the end of the tenth growing season. On the open-pine site, 37% of common chokecherry survived after 10 years, while survival of saskatoon serviceberry and silverberry were 31% and 16%, respectively. The highest survival occurred with silver buffaloberry with 63% at the end of the tenth season. Planting nursery stock was the only successful means for establishing common juniper.

On both areas, common chokecherry and saskatoon serviceberry established from bare-root transplants had poor growth rates, but each were taller on the old-burn site after 5 years (figs. 8 and 9). Saskatoon serviceberry had completely died out by the tenth year on the old-burn site, but tripled in growth from the fifth to the tenth year on the open-pine site (fig. 8). Silverberry was superior to both common chokecherry and saska-

Figure 7.—Mountainmahogany plants established 10 years previously from potted seedlings have survived well on both the old-burn (A) and open-pine (B) sites.

toon serviceberry in growth. The silverberry plants grew taller on the old-burn study area than at the open-pine site (fig. 10). This same trend was observed with silver buffaloberry (fig. 11).

DISCUSSION

Germination of Shrubs

Common chokecherry, snowbrush ceanothus, and mountainmahogany varied widely in germination success in the greenhouse and in the field during the 3 years of planting. Germination of antelope bitterbrush seeds in the greenhouse was higher than that obtained at both the open-pine and old-burn sites. Common chokecherry germination was higher in the field than in the greenhouse. Mountainmahogany germination was highest at the open-pine site and lowest on the old-burn site.

The effects of treating seeds to break dormancy varied with species. Scarification improved germination slightly for common chokecherry. The thiourea treatment increased the emergence of snowbrush ceanothus.

Better seedling emergence of most species on the open-pine site may have been caused by more favorable soil moisture conditions resulting from higher fall precipitation at that site combined with partial shading provided by the pine overstory. For antelope bitterbrush, Nord (1965) states that during late fall, winter, and early spring, the soil must be moist at least to the depth of the planted seed.

Factors affecting germination success in the greenhouse were more related to method of seeding

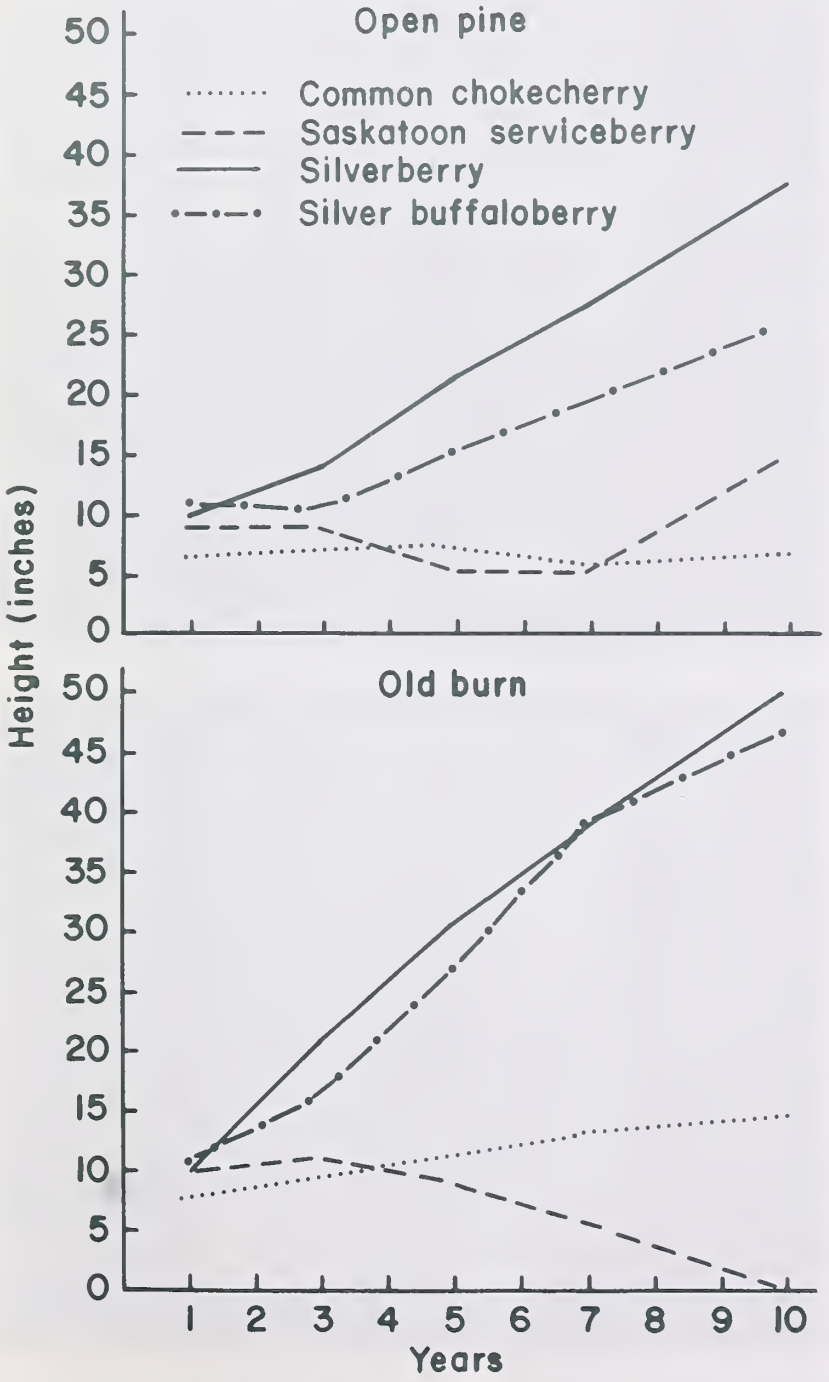


Figure 8.—Comparative growth curves for bare-root stock of four shrub species during the first seven growing seasons and at the end of the tenth growing season.

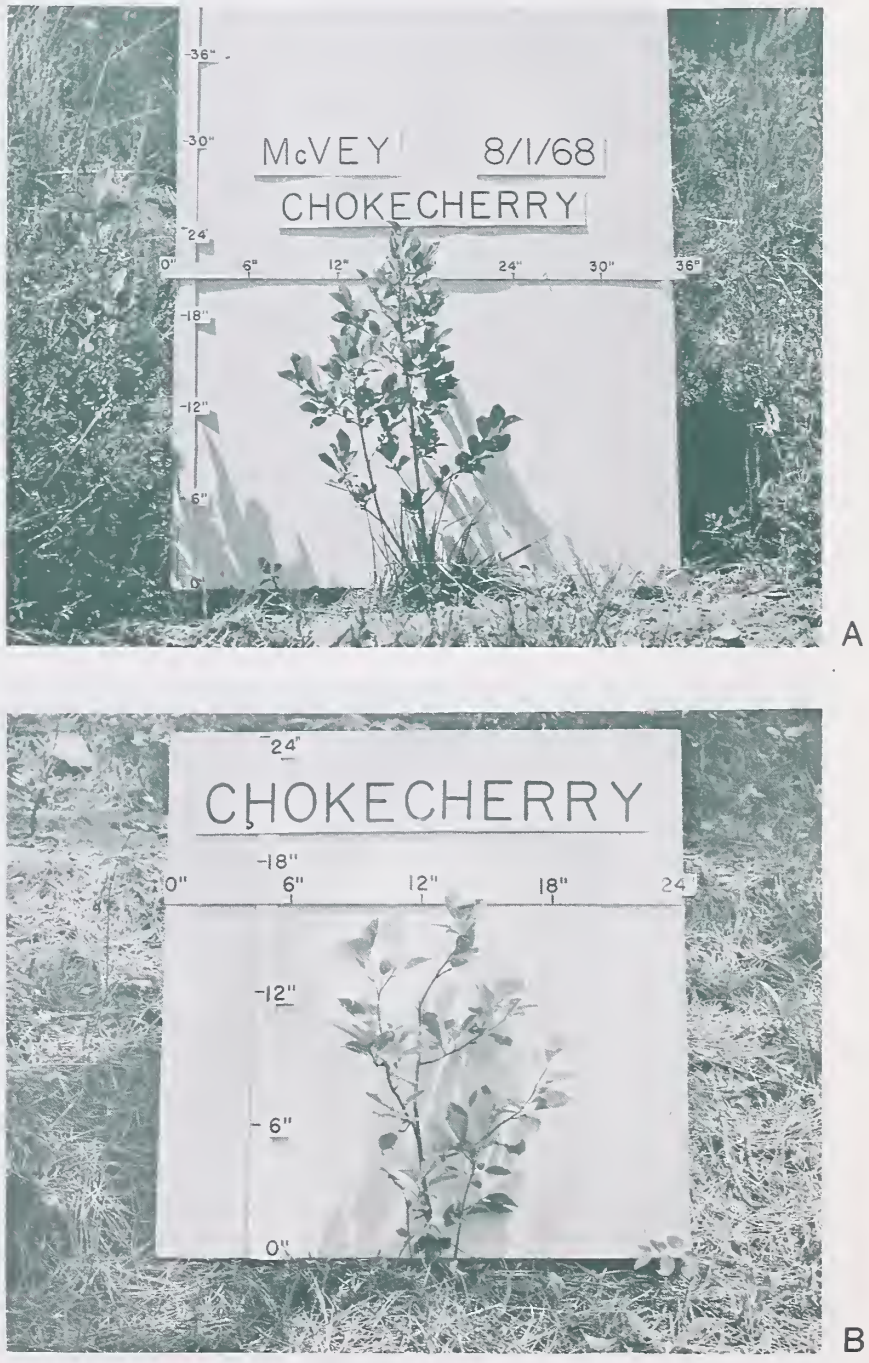


Figure 9.—Common chokecherry, although surviving well on both the old-burn (A) and open-pine (B) sites, has remained small because of winter dieback.

treatment to break dormancy than other factors. Adequate soil moisture conditions were maintained at all times. The wide variability in germination results obtained with scarification, boiling, and thiourea treatment indicates a need for additional studies to develop techniques for breaking seed dormancy.

Factors Affecting Browse Establishment

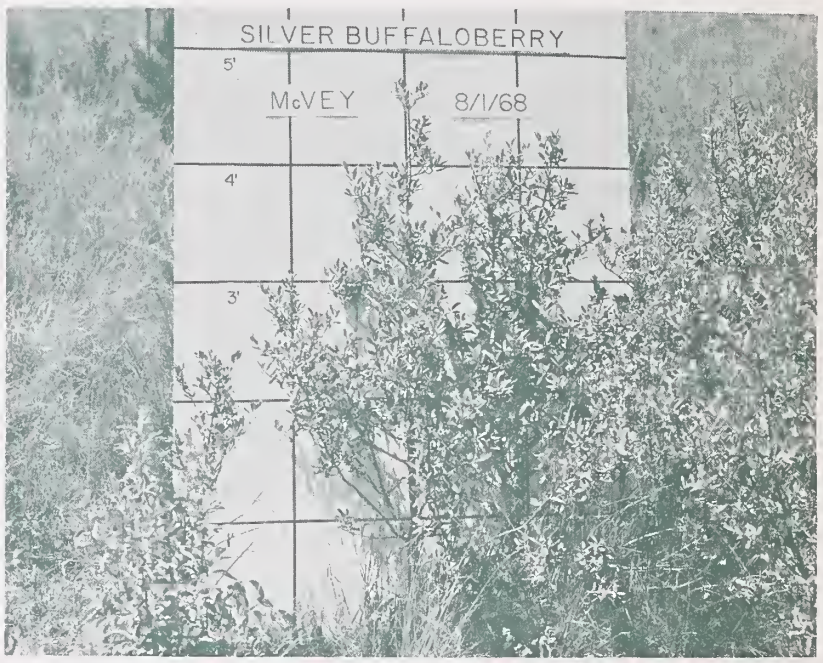
Comparisons of browse establishment between the old-burn and open-pine locations indicated the burn area was more suitable for shrub revegetation. A major reason for this is that the old-pine site was not disturbed (i.e., fire, although competing herbaceous vegetation was partially controlled by cultivation on both sites). Competition with pine alone is a major factor influencing the difference in survival at the two locations. Higher mortality of planted browse species the first 2 years and their subsequent lower survival the remaining 8 years on the open-pine area probably was due to competition for soil moisture and sunlight. Consequently, survival was generally higher at the old-burn site.

The growth trend of the browse plants coincided closely with the survival trend. Containerized stock of most species were more hardy than plants established from hand planting of seeds during the first, and in some instances, during the second growing season because of more extensive root development and partial protection provided by the planting container. The plants on the old-burn site were generally several inches taller than those growing on the open-pine site. Average heights generally increased each growing season, except for a few species such as common chokecherry where average heights decreased during

A

B

Figure 10.—Silverberry plants established from containerized stock have shown excellent growth on the old-burn (A) and good growth at the open-pine site (B). Profuse root sprouting occurred on both sites.



A

B

Figure 11.—Silver buffaloberry nursery stock grew well, especially on the old-burn site (A) and to a lesser extent at the open-pine site (B).

some years because of winter dieback. Common chokecherry and saskatoon serviceberry showed this characteristic more than other species. Antelope bitterbrush had the greatest average height and height increase of all species whether started from hand seeding or containerized seedlings during the first 5 years, indicating its suitability for the Black Hills. However, by the tenth year, mountainmahogany was slightly taller than antelope bitterbrush but had much less total foliage. Silverberry and silver buffaloberry bare-root stock grew considerably taller than either common chokecherry or saskatoon serviceberry and equal to or better than antelope bitterbrush and mountainmahogany indicating a good tolerance for the two areas.

The effect of drought on seedling growth and survival was difficult to determine. Some shrub mortality was definitely drought caused. For instance in the first year of the study, 71% of the mountainmahogany seedling mortality occurred during a drought period in May. However, only 20%-51% of total mortality of the other species occurred during the same period. Seedling mortality was greater on the old-burn site than the open-pine site during this same period.

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Information is presented on establishment, survival, and growth of seven selected browse species in a ponderosa pine forest over a 10-year period. Methods of establishment included hand seeding and planting bare-root and containerized stock. Success of different methods differed with shrub species.

Keywords: Browse, establishment, survival, growth.

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Rocky Mountains

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